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POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY
IN UNDERDEVELOPED COUNTRIES WITH REGARD
TO THEIR ECONOMIC MEANS AND MODERN TECHNOLOGY

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POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY IN
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MEANS AND MODERN TECHNOLOGY

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It's commonly believed that the semiconductor industry is synonym of a very advanced technology, which may be put profitably to work only in the more industrialized countries. Advanced technologies are not however, the single reason for the widely held opinion that the semiconductor industry does not fit the present needs of the less developed countries. Lack of demand, the high import requirements and the unbalancing effect of a semiconductor industry not integrated within a well established electronic industry, provide further arguments for such a belief. It's our opinion that establishing a semiconductor industry might be a fairly good investment of the scarce resources of at least some of the new emerging countries, and that therefore planners and economists should not overlook it as they seem to do. The first factor on which we like to call the attention is the recent development of some basic technologies, substantially founded upon a more solid know-how (and in some cases upon what we would call "tricks") of processes that permit to avoid many of the big difficulties encountered in early years. The yield of production lines in terms of marketable units has increased to 70-90% as compared to 20-40% around 1954. Yet, the great number of highly repetitive elementary operations, necessary in the building-up of semiconductor devices, are well suited for a production through unexperienced manpower, who may acquire, in a very short time, all the ability and skill necessary. Apart from unskilled manpower, the semiconductor industry requires a certain number of very well prepared technicians. Their number being proportional to the degree of sophistication of the devices produced and to the amount of original research that is carried out. If a plant for the production of 500 thousand high power silicon rectifier per annum might require 50 workers and 10 to 12 qualified scientists and engineers, a plant of the same size for entertainment transistor, might produce 4-5 million marketable units per years with the same amount of unskilled labour and 6 or 7 qualified technicians. We do agree that the new emerging countries might be lacking a large amount of highly qualified technicians, but not the few that are required for low quality production. Cheap manpower has in the semiconductor industry a very important role because of the quick rate of obsolescence that the continuous improvements in the state of the art imposes upon fixed machinery. Another main characteristic of the semiconductor industry is the convenience of a low fixed investment also in the advanced countries because highly automatic lines of production need a large amount of capital and the time necessary for the complete design may render obsolete device. We have shortly discussed the problem from a general viewpoint; to give more strength to our argument we shall now try to give some estimates of hypothetical comparative costs. Let us consider two representative semiconductor devices, characterized by a well known technology comparing the cost of the units in two different countries:

1) Italy (IT) where manpower cost of \$ per hour has been considered, and where some automatic operations are still convenient; 2) hypothetical underdeveloped country (HUC) where a manpower cost of 35 \$ per hour has been considered. The devices taken into consideration is: a) low-power (200 mW) general purpose germanium alloy transistor (GeLP), 2 millions good units per year (considering a yield of 80%). IT - Line investment from wafer sorting and cutting to automatic final testing, including headers production 140.000 \$; HUC - Line investment, same considerations, with manual final testing 70.000\$

Cost of a marketable unit (cents)				
	IT		HUC	
Materials and parts	14,00	62,3%	11,00	63,1%
Chemical gases, deion, water	1,00	4,4%	2,00	11,5%
Manpower (30 workers+ 2 foremen)	3,70	16,4%		
Manpower (60 workers+5 foremen)			2,50	14,4%
Depreciation:	3,50	15,5%	1,75	10,0%
Interest of investments	0,28	1,2%	0,21	1,2%

a) approximately TOTAL: 22.48 100 a) 17.46 100 a)

The cost per unit is calculated on the basis of the prices of the parts and apparatus as they are available in Italy. The rate of interest taken into account was 8% in Italy and 12% in the hypothetical underdeveloped country to consider the different availability of capital. Depreciation was calculated according to the prevailing standards of the industry upon the basis of a two years obsolescence. It is however clear that in an underdeveloped country where technological progress is not so quick, depreciation might be spread over a much longer period. The more so if production is meant for the entertainment market. We do not pretend to give here the absolute values, which may be perhaps slightly lower, but to furnish a comparison between the two possibilities; the cost HUC is about 20% lower. The difference between the two investments is mainly due to: 1) the cost of automatic test equipment which can be evaluated between 30,000 and 40,000 \$; 2) the cost of automatic machinery which is necessary with a relatively low number of workers. The last argument causes also a decrease for HUC, in the cost of direct materials and parts, which are less elaborated because of more manual operation. We took into account a greater difficulty for HUC to get proper chemicals, and especially good quality gases. The figure of 2 \$ per unit, in that case, depends largely from the conditions of the corresponding industry in each country.

b) GeHP - 500,000 good units per year (considering a yield of 70% - power (3-20W) general purpose Germanium transistor (GeHP))

IT - line investment from wafer sorting and cutting to final testing (we do not consider here the automatic test equipment because yet considered from GeLP), including headers manufacturing --- 50,000 \$ HUC \$ line investment, same conditions as above, plus 6,000 \$ of final test equipment, including headers manufacturing --- 56,000 \$

Cost of a good unit (cents)				
	IT		HUC	
Material and parts	22.4	49.0%	22.4	53.7%
Chemical gases deio, water	3.0	6.5	6.0	14.4
Manpower (30 workers + 2 foremen)	15.0	32.7		
Manpower (30 workers + 3 foremen)			6.4	15.3
Depreciation:	5.0	10.9	6.0	14.4
Interest:	0.4	0.9	0.9	2.2
<u>TOTAL:</u>	45.8	100%	41.7	100%

This represents a completely different situation, the difference in two cases being about 10% in favour of HUC. This is only due to the manpower cost; the other costs are equal or higher, apart from the already mentioned considerations on depreciation. The power transistor is the typical case for which, as far as we know, automatic productions are reduced to a minimum; the manpower is the greatest part of manufacturing cost. In fact, the two cases presented here, GeLP and GeHP, are in our opinion, the two extreme possibilities between which we may classify, from the economical viewpoint the greatest majority of the semiconductor devices actually produced. We did not take into consideration here, the investment for the general services because that is a function of the size of plant and of climatic conditions which cannot be generalised. Moreover, the possible higher cost of installation in HUC may be compensated by the lower cost of less automatic equipment and of maintenance.

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